

FORM PTO-1390 (Modified) (REV 10-95)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER 1500	
INTERNATIONAL APPLICATION NO. PCT/DE 00/01929		U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/763254	
INTERNATIONAL FILING DATE JUNE 19, 2000		PRIORITY DATE CLAIMED JUNE 19, 1999	
TITLE OF INVENTION PIEZOELECTRIC ACTUATOR			
APPLICANT(S) FOR DO/EO/US Klaus-Peter SCHMOLL, Friedrich BOECKING			
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:			
<ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1). 4. <input type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date. 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371 (c) (2)) <ol style="list-style-type: none"> a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)). 7. <input type="checkbox"/> A copy of the International Search Report (PCT/ISA/210). 8. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3)) <ol style="list-style-type: none"> a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 9. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 10. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). 11. <input type="checkbox"/> A copy of the International Preliminary Examination Report (PCT/IPEA/409). 12. <input type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)). 			
Items 13 to 18 below concern document(s) or information included:			
<ol style="list-style-type: none"> 13. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 14. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 15. <input checked="" type="checkbox"/> A FIRST preliminary amendment. A SECOND or SUBSEQUENT preliminary amendment. 16. <input type="checkbox"/> A substitute specification. 17. <input type="checkbox"/> A change of power of attorney and/or address letter. 18. <input checked="" type="checkbox"/> Certificate of Mailing by Express Mail 19. <input type="checkbox"/> Other items or information: 			
<p style="font-size: 2em; font-family: cursive;">EF 215 953 061 US</p>			

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.53) 09/763254	INTERNATIONAL APPLICATION NO. PCT/DE 00/01929	ATTORNEY'S DOCKET NUMBER 1500
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20. The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

- | | |
|--|-------------------|
| <input type="checkbox"/> Search Report has been prepared by the EPO or JPO | \$930.00 |
| <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) | \$720.00 |
| <input type="checkbox"/> No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) | \$790.00 |
| <input checked="" type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO | \$1,070.00 |
| <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) | \$98.00 |

ENTER APPROPRIATE BASIC FEE AMOUNT =**\$1,000.00**
 Surcharge of **\$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).
\$0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	8 - 20 =	0	x \$18.00	\$0.00	
Independent claims	1 - 3 =	0	x \$80.00	\$0.00	
Multiple Dependent Claims (check if applicable). <input type="checkbox"/>				\$0.00	

TOTAL OF ABOVE CALCULATIONS =**\$1,000.00**
 Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). ☐
\$0.00**SUBTOTAL =****\$1,000.00**
 Processing fee of **\$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).
\$0.00**TOTAL NATIONAL FEE =****\$1,000.00**
 Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). ☐
\$0.00**TOTAL FEES ENCLOSED =****\$1,000.00**

Amount to be: refunded	\$
charged	\$

- ☐ A check in the amount of _____ to cover the above fees is enclosed.
- ☒ Please charge my Deposit Account No. **19-4675** in the amount of **\$1,000.00** to cover the above fees.
A duplicate copy of this sheet is enclosed.
- ☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **19-4675** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

STRIKER, STRIKER & STENBY
103 EAST NECK ROAD
HUNTINGTON, NEW YORK 11743

SIGNATURE

MICHAEL J. STRIKER

NAME

27233

REGISTRATION NUMBER

FEBRUARY 20, 2001

DATE

09/763254

JC02 Rec'd PCT/PTO 2 0 FEB 2001

UNITED STATES PATENT AND TRADEMARK OFFICE

Examiner: Group: Attorney Docket # 1500

Applicant(s) : SCHMOLL, K., ET AL

Serial No. :

Filed : Simultaneously

For : PIEZOELECTRIC ACTUATOR

SIMULTANEOUS AMENDMENT

February 19, 2001

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

S I R S:

Simultaneously with filing of the above identified application
please amend the same as follows:

In the Claims:

Claim 5 line 1 and 2 delete "one of claims 2 to 4", substitute with "claim 2".

Claim 8 line 1 and 2 delete "one of claims 2 to 7", substitute with "claim 2".

REMARKS:

This Amendment is submitted simultaneously with filing of the above identified
application.

With the present Amendment applicant has amended the claims so as to eliminate
their multiple dependency.

Consideration and allowance of the present application is most respectfully
requested.

Respectfully submitted,

A handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke extending to the right.

Michael J. Striker
Attorney for Applicant(s)
Reg. No. 27233

VERIFICATION OF TRANSLATION

I, DAVID CLAYBERG

of 948 15th St., Ste. 4
Santa Monica, CA 90403-3134

declare that I am a certified translator well acquainted with both the German and English languages, and that the attached is an accurate translation, to the best of my knowledge and ability, of the International Patent Application PCT/DE 00/01929.

Signature



David Clayberg

Date

16 FEB 2001

2/PRTS

09/763254
JC02 Rec'd PCT/PTO 20 FEB 2001

Piezoelectric Actuator

Prior Art

The invention relates to a piezoelectric actuator, for example for actuating a mechanical component such as a valve or the like, according to the features contained in the preamble to the main claim.

It is generally known that using the so-called piezoelectric effect, a piezoelectric element can be constructed out of a material with a suitable crystalline structure. The application of an external electrical voltage causes a mechanical reaction of the piezoelectric element which, depending on the crystalline structure and the region to which the electrical voltage is applied, produces a compression or tension in a predictable direction. This piezoelectric actuator can be constructed of a number of layers (multilayered actuators), wherein the electrodes via which the electrical voltage is applied are respectively disposed between the layers. During operation of the piezoelectric actuator, care must be taken that mechanical stresses in the layer structure do not cause undesirable fractures to form.

Advantages of the Invention

The piezoelectric actuator described at the beginning, which can be used, for example, to actuate a mechanical component, is advantageously designed with a multilayered structure of piezoelectric layers with electrodes disposed

between them. With a contacting of the electrodes on alternating sides, a neutral phase is produced in the region between every pair of piezoelectric layers. Since the electrodes, which are each contacted on one side, are integrated into the layer structure in comb fashion, the electrodes disposed one after another in the direction of the layer structure must respectively be contacted in an alternating fashion on opposite sides from one another.

The electrodes contacted on one side cannot extend all the way to the opposite side since otherwise, voltage arcing can destroy the piezoelectric actuator. When the piezoelectric actuator is actuated, i.e. when a voltage is applied between the electrodes on opposite sides in the layer structure, different mechanical forces are produced in the vicinity of the electrodes as well as in the non-contacted neutral phases, which can lead to mechanical stresses and fracture formation in the piezoelectric actuator.

According to the invention, when the piezoelectric actuator is clamped in place perpendicular to the layer structure, with a shape of the multilayered structure, an intentionally increased mechanical stress is advantageously exerted in the vicinity of the neutral phases in order to prevent fracture formation.

In a first advantageous embodiment, at least one outer cover layer of the multilayered structure on the outer end face is embodied so that it has a thickening in the vicinity of the neutral phases and thus permits an increased initial stressing force to be intentionally exerted here. The

thickening can be produced in a simple manner, for example by means of grinding the cover layer.

In another advantageous embodiment, an insulating layer is disposed between the layers of the multilayered structure and this insulating layer has a thickening in the vicinity of the respective neutral phases and therefore functions in a comparable fashion to the first exemplary embodiment.

Another embodiment advantageously has especially embodied electrodes in the multilayered structure, which likewise have a thickening in the vicinity of the respective neutral phases, wherein with regard to the various embodiments mentioned above, some or all of the features may be combined with one another.

These and other features of preferred modifications of the invention ensue not only from the claims but also from the specification and the drawings, wherein the individual features can be respectively realized singly or multiply in the form of sub-combinations in the embodiment of the invention and in other areas and can represent advantageous and intrinsically patentable embodiments which are claimed herein.

Drawings

Exemplary embodiments of the piezoelectric actuator according to the invention will be explained in conjunction with the drawings.

- Fig. 1 is a section through a piezoelectric actuator with a multilayered structure of electrodes and piezoelectric ceramic layers;
- Fig. 2 is a detailed section through the layer structure in the vicinity of the neutral phases, without the application of an electrical voltage
- Fig. 3 is a detailed section through the layer structure in the vicinity of the neutral phases, with the application of an electrical voltage;
- Fig. 4 shows a first exemplary embodiment of a piezoelectric actuator in which an outer cover layer has thickenings on the side surfaces, in the vicinity of the neutral phases;
- Fig. 5 shows a second exemplary embodiment of a piezoelectric actuator in which an outer cover layer has thickenings on the side surfaces, in the vicinity of the neutral phases;
- Fig. 6 shows a third exemplary embodiment of a piezoelectric actuator in which the electrodes have thickenings in the vicinity of the neutral phases; and
- Fig. 7 shows a fourth exemplary embodiment of a piezoelectric actuator in which an insulating layer is disposed between the layers and has thickenings on the side surfaces, in the vicinity of the neutral phases.

Description of the Exemplary Embodiments

Fig. 1 shows a piezoelectric actuator 1 which is comprised in an intrinsically known manner of piezoelectric foils 2 of a quartz material with a suitable crystalline structure so that that using the so-called piezoelectric effect, the application of an external electrical voltage to electrodes 3 and 4 via contact surfaces 5 and 6 causes a mechanical reaction of the piezoelectric actuator 1.

Fig. 2 depicts an enlarged region of the piezoelectric actuator 1 in which the electrodes 3 and 4 are shown, wherein the contacting of the electrodes 4 with the contact surface 6 is also shown here. Since the electrodes 3, due to the different polarity, must be kept spaced apart from this contact surface 6, neutral phases are produced here which are shown by way of example in the form of the neutral phase 7. Due to the therefore spatially different occurrence of the piezoelectric effect, mechanical stresses are produced in the neutral phase 7 causing damage to the material, which is schematically depicted with the wavy line 8.

Fig. 3 shows the region from Fig. 2, with the application of an electrical current, wherein the mechanical reaction of the piezoelectric actuator caused by this is indicated with arrows 9 and 10. It is clear here that in the vicinity of the neutral phase 7, less of an expansion in the direction of the arrows 9 is produced and therefore an exertion of force is produced in the direction of the arrow 10, which leads to a fracture formation in the vicinity 8 of the neutral phase.

A first exemplary embodiment of the invention will be explained in conjunction with Fig. 4, in which an outer cover layer 11 is disposed on the multilayered structure and is provided with a thickening 12 in the vicinity of the neutral phases 7, which in the outer maximum can reach an order of magnitude of 2 to 8 μm . When the piezoelectric actuator 1 is clamped in place, this thickening 12 permits an initial stress to be exerted in the vicinity of the neutral phases 7, which prevents the fracture formation in the vicinity 8 of the electrodes 3 and 4 (see Fig. 3).

Fig. 5 shows a second exemplary embodiment which has an outer cover layer 11 with thickenings 13 which are disposed at opposite corners of the piezoelectric actuator 1. The neutral phases 7 here are likewise embodied at the corners since in this exemplary embodiment, the contacting of the electrodes 3 and 4 takes place via a contact surface 14 attached to the corner and a contact surface diagonally opposite from it, which is not shown.

In the exemplary embodiment according to Fig. 6, a thickening is produced in the vicinity of the neutral phases 7 by means of a local thickening of the electrodes 3 and 4 exclusively in the vicinity of the neutral phases 7.

Another exemplary embodiment according to Fig. 7 has a piezoelectric actuator 1 in which an insulating layer 15 that is extra-thick here is inserted between the piezoelectric layers 2 in the vicinity of the neutral phases 7 in order, when the piezoelectric actuator 1 is clamped in place, to exert an initial stress here as well, which prevents a fracture formation.

Claims

1. A piezoelectric actuator with

- a multilayered structure of piezoelectric layers (2) and electrodes (3, 4) disposed between them,
- an alternating lateral contacting (5, 6) of the electrodes (3, 4), wherein in the region between two piezoelectric layers, which contains one of the electrodes (3, 4) that are respectively contacted on opposite sides from one another, there is a neutral phase (7) without an electrode layer, and
- a shape of the multilayered structure which permits an increased mechanical stress to be exerted in the vicinity of the neutral phases (7) when the piezoelectric actuator (1) is clamped in place perpendicular to the layer structure.

2. The piezoelectric actuator according to claim 1, characterized in that

- at least one outer cover layer (11) of the multilayered structure on the outer end face is embodied so that it has a thickening (12; 13) in the vicinity of the neutral phases (7).

3. The piezoelectric actuator according to claim 2, characterized in that

- the thickening (12) is disposed on opposite sides of the cover layer (11), in accordance with the placement of the neutral phases (7).

4. The piezoelectric actuator according to claim 2, characterized in that

- the thickening (13) is disposed at diagonally opposite corners of the cover layer (11), in accordance with the placement of the neutral phases (7).

5. The piezoelectric actuator according to one of claims 2 to 4, characterized in that

- the thickening is produced by grinding the cover layer.

6. The piezoelectric actuator according to claim 1, characterized in that

- an insulating layer (15) is disposed between (some or all?) of the layers of the multilayered structure and has a thickening in the vicinity of the respective neutral phases (7).

7. The piezoelectric actuator according to claim 1, characterized in that

- the electrodes (3, 4) of the multilayered structure each have a thickening in the vicinity of the respective neutral phases (7).

8. The piezoelectric actuator according to one of claims 2 to 7, characterized in that

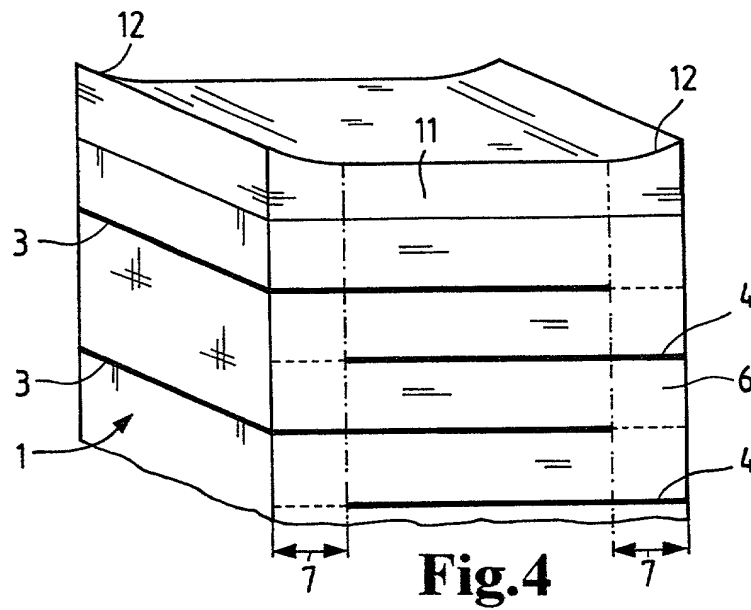
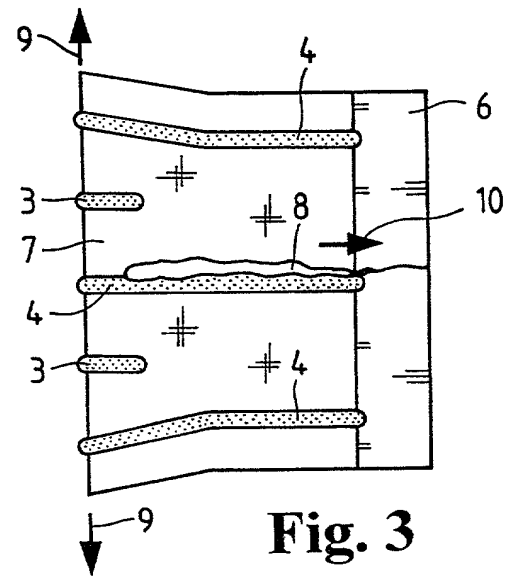
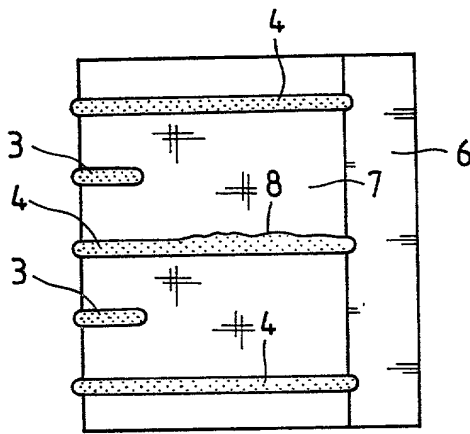
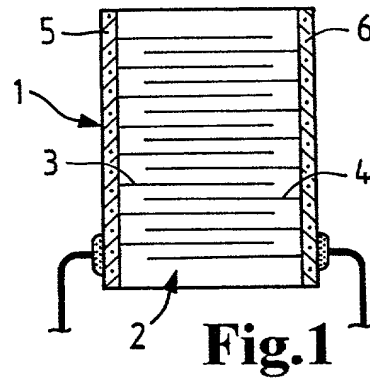
- some or all of the features of these claims are combined with one another.

Abstract

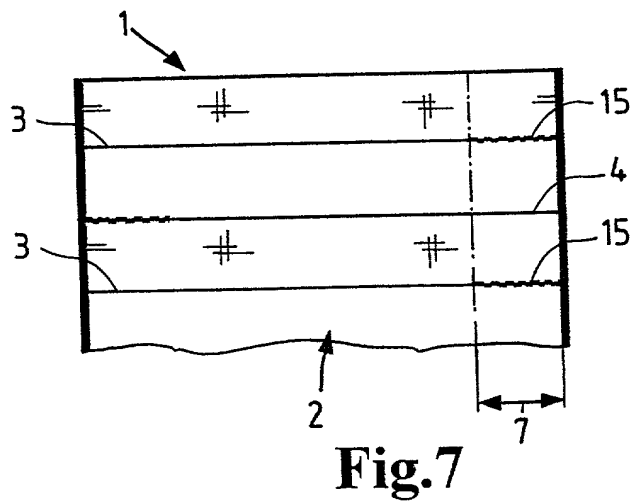
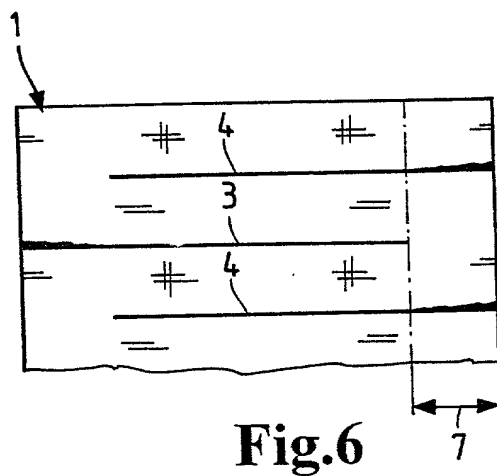
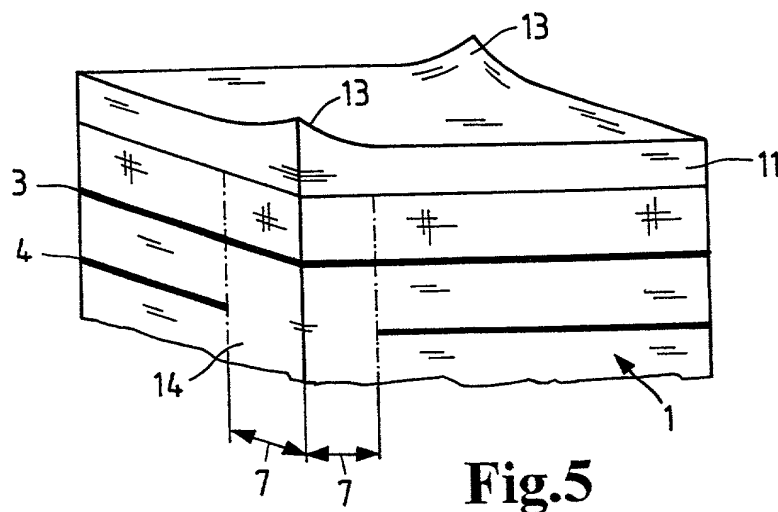
A piezoelectric actuator, e.g. for actuating a mechanical component, is proposed, which has a multilayered structure of piezoelectric layers (2) with electrodes (3, 4) disposed between them. With a contacting (5, 6) of the electrodes (3, 4) on alternating sides, there is a neutral phase (7) without an electrode layer, in which fracture formation can occur, which can be prevented by means of a shape of the multilayered structure which permits an increased mechanical stress to be exerted in the vicinity of the neutral phases (7) when the piezoelectric actuator (1) is clamped in place perpendicular to the layer structure.

(Fig. 4)

1 / 2



2 / 2



DECLARATION AND POWER OF ATTORNEY FOR NATIONAL STAGE OF PCT PATENT APPLICATION

As a below-named inventor, I hereby declare that:

Klaus-Peter SCHMOLL
Friedrich BOECKING

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **PIEZOELECTRIC ACTUATOR** the specification of which was filed as PCT International Application number PCT/DE 00/01929 on June 19, 2000.

I hereby state that I believe the named inventor or inventors in this Declaration to be the original and first inventor or inventors of the subject matter which is claimed and for which a patent is sought.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365 (b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior foreign application(s):

Priority claimed:

<u>199 28 177.7</u>	<u>GERMANY</u>	<u>JUNE 19, 1999</u>	<u>X</u>	
(Number)	(Country)	(Date filed)	Yes	No
<u> </u>	<u> </u>	<u> </u>	Yes	No
(Number)	(Country)	(Date filed)		

As a named inventor, I hereby appoint the following attorney to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Michael J. Striker, Reg. No. 27233

Direct all telephone calls to Striker, Striker & Stenby at telephone no.: (631) 549 4700 and address and all correspondence to:

STRIKER, STRIKER & STENBY
103 East Neck Road
Huntington, New York 11743
U.S.A.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statement may jeopardize the validity of the application or any patent issued thereon.

Signature: <i>Klaus-Peter Schmolle</i>	Date: <i>14.02.01</i>	Residence and Full Postal Address: Richard-Wagner-Strasse 3 74251 Lehensteinsfeld Germany <i>DEX</i>
Full Name of First or Sole Inventor: Klaus-Peter SCHMOLL	Citizenship: GERMAN	
Signature: <i>Friedrich Boecking</i>	Date: <i>22.02.01</i>	Residence and Full Postal Address: Kahlhieb 34 70499 Stuttgart Germany <i>DEX</i>
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Full Name of Third Inventor:	Citizenship:	
Signature:	Date:	Residence and Full Postal Address:
Full Name of Fourth Inventor:	Citizenship:	
Signature:	Date:	Residence and Full Postal Address:
Full Name of Fifth Inventor:	Citizenship:	
Signature:	Date:	Residence and Full Postal Address:
Full Name of Sixth Inventor:	Citizenship:	
Signature:	Date:	Residence and Full Postal Address:
Full Name of Seventh Inventor:	Citizenship:	
Signature:	Date:	Residence and Full Postal Address:
Full Name of Eighth Inventor:	Citizenship:	
Signature:	Date:	Residence and Full Postal Address:
Full Name of Ninth Inventor:	Citizenship:	